Specification

1. Title of the invention

A battery residual capacity display device

2. Claims

(1) A battery residual capacity display device comprising an arithmetic circuit for calculating a battery residual capacity based on an electric charge of a charge/discharge of a battery, and a display for displaying the battery residual capacity, characterized in that the battery residual capacity display device further comprises a voltage detection means for detecting a battery voltage, and a cut off circuit for cutting off the power supply from a battery to the residual capacity display device at a time when the battery voltage detected by the voltage detection means falls below a predetermined level.

3. Detailed description of the invention

[Industrial field of the invention]

The present invention relates to a battery residual capacity display circuit that detects and displays a residual capacity of a rechargeable battery such as a rechargeable nickel cadmium battery.

[Prior art]

A battery residual capacity display device monitoring an electric charge of a charge/discharge of a battery is composed of an arithmetic circuit and a microcomputer comprising a memory circuit. A continuous battery output voltage is applied on the battery residual capacity display device, and the battery residual capacity display device consumes current from the battery.

[Problem to be solved by the invention]

When a battery is left untouched for a long period of time, the battery can be over-discharged, and leakage may occur. In general, when a battery has been left untouched, a residual capacity display device usually switches mode, based on an outside signal, to low current consumption mode. However, even if it is in low current consumption mode, the battery is in a state of load discharge, and leakage may result when the battery remains in that state for an extended period.

The present invention is provided in light of the problem mentioned above, and the objective is to provide a battery residual capacity display device that does not cause battery deterioration due to current consumption.

[Means to solve the problem]

The present invention includes a voltage detection means for detecting a battery voltage and a cut off circuit for cutting off the power supply from a battery to the residual capacity display device at a time when a battery voltage detected by the voltage detection means falls below a predetermined level.

[Function]

When a battery voltage falls below a predetermined level in the voltage detection means, the power supply from a battery to the residual capacity display device is cut off by the cut off circuit.

[Embodiment]

Below, a preferable embodiment of the present invention is described with reference to the figures. First, a circuit shown in figure 6, which is the underlying condition of the present invention, will be described. Specifically, a residual capacity display module A is connected to recharger 13, and when battery 1 is being charged, the charging current flows in the positive pole direction from recharger 13 to battery 1, through sensor resistance 2, and back to recharger 13. At this time, the charging current is converted to a voltage by sensor resistance 2. The converted voltage is converted to a digital value by A/D converting circuit 3, and is inputted to arithmetic circuit 5. Arithmetic circuit 5 reads in the time used to convert a single A/D conversion provided by timer circuit 4, and a capacity of recharged electric charge is calculated according to these two data (voltage value and time). Arithmetic circuit 5 repeats this process, sums the measured capacity of recharged electric charge, and saves the result in first memory 6.

Second memory 7, for example, stores a rating capacity of battery 1. At this time, second memory 7 may consider capacitance variability, and input an average capacity value. Arithmetic circuit 5 compares a value of first memory 6 to a value of second memory 7, then calculates, for example, what percentage the value of first memory 6 is relative to the value of second memory 2, and outputs the result to output circuit 8. Output circuit 8 is constructed of 5 ports, and each port P_1-P_5 of arithmetic circuit 5 is sorted according to percentages as shown in figure 7. Each port represents a level of residual capacity. For example, if the residual capacity, which is a ratio of first memory 6 to second memory 7, exceeds the sorted percentage, each port P_1-P_5 will be in a state of H-level.

Output circuit 8 is constructed by five transistors Q_1-Q_5, and is connected to display 9. Display 9 comprises, for example, light-emitting diodes LD_1-LD_5, and light-emitting diodes LD_1-LD_5 light up in response to an output condition of output circuit 8. In other words, with reference to figure 6, light-emitting diode LD_1 lights up

when the residual capacity of battery 1 is below 20%, light-emitting diodes LD_1-LD_2 light up when the residual capacity of battery 1 is above 20% but below 40%, light-emitting diodes LD_1-LD_3 light up when the residual capacity of battery 1 is above 40% but below 60%, light-emitting diodes LD_1-LD_4 light up when the residual capacity of battery 1 is above 60% but below 80%, and all light-emitting diodes LD_1-LD_5 light up when the residual capacity of battery 1 is above 80%. In the example shown in figure 7, output circuit 8 acts as an open-collector output. In addition, a format of an output circuit may be in binary. Further, LCDs may be used in place of light-emitting diodes.

When recharger 13 is connected to residual capacity display module A, the signal is inputted to arithmetic circuit 5 via input circuit 10, and a state of charge is acknowledged. When the charging is complete and recharger 13 enters a state of discharge, recharger 13 separates from residual capacity display module A. Then, switch 12 is closed, and load 11 is connected to residual capacity display module A and battery 1. This time, discharge current flows in an opposite direction as before. In other words, the current flows from the positive pole of battery 1 to sensor resistance 2 via load 11, and returns to the negative pole of battery 1. At this time, residual capacity display module A operates according to the same operation principles with the exception that the polarity of the current value, converted to voltage by sensor resistance 2, is opposite to the polarity of the current value in the state of charge.

In a state of discharge, the polarity of the current reverses and arithmetic circuit 5 subtracts the summed value of first memory 6. Therefore, the light-emitting diodes of display 9 turn off one by one while the discharging continues. In a state of discharge, when switch 12 is turned on, an H-level signal is inputted to input circuit 10, and a state of discharge is acknowledged by arithmetic circuit 5.

When neither recharger 13 nor load 11 is connected, arithmetic circuit 5 acknowledges battery 1 to be untouched, and switches mode to low current consumption mode.

Next, a portion of the present invention will be explained. The present invention, as shown in figure 1, includes A/D conversion circuit 14, which is a voltage detection means for detecting a battery voltage in a circuit of figure 5, and a power source voltage detection circuit 15 for detecting power source voltage of recharger 13.

Next, its operation will be explained. In a state of charge, a charging battery voltage is inputted in A/D conversion circuit 14, converted to a digital value, and inputted to arithmetic circuit 5 configured of a microcomputer. While charging,

arithmetic circuit 5 detects voltage -ΔV by measuring a battery voltage. Voltage -ΔV means an amount a battery voltage decreases when performing a -ΔV control, which is commonly used in charge control. When this voltage is detected, it indicates the battery has been fully charged. In other words, after detecting the peak of a battery voltage, charging becomes complete at a time when the voltage decreases by ΔV (V) from the peak value. Further, when -ΔV is detected, arithmetic circuit 5 outputs a signal to recharger 13, and recharger 13 stops the charging output (current) to battery 1 based on this signal.

A signal of power source voltage detection circuit 15 is inputted to arithmetic circuit 5, and arithmetic circuit 5 detects whether the power source voltage of recharger 13 is inputted or not. Operation of power source voltage detection circuit 15 will be explained below. Specifically, when charging stops, the battery voltage falls immediately. If recharger 13 is disconnected to power outlet, the battery voltage falls due to the charging stop, and arithmetic circuit 5 acknowledged that -ΔV is occurred. Thus, in order to determine whether recharger 13 operates in a normal condition or not, arithmetic circuit 5 monitors the operation of recharger 13 via power source voltage circuit 15.

Table 1 shows a relationship between -ΔV detection and the signal of power source voltage detection circuit 15.

-ΔV	Power source voltage detection circuit	Arithmetic circuit acknowledgement
Detected	H	-ΔV valid
Detected	L	-ΔV invalid Charging stops
Not Detected	H	Charging
Not Detected	L	Charging stops

Table 1

H of power source voltage detection circuit 15 indicates recharger 13 is turned on, and L indicates recharger 13 is turned off.

Arithmetic circuit 5, once it detects voltage -ΔV, determines that battery 1 is fully charged. At that point, the charged residual capacity calculated from a charging current is set to 100%. In other words, it sets content from first memory 6 to be equal to content of second memory 7. This is to correct an error that may occur when the measured residual capacity of battery 1 comes out to be smaller than the actual measurement due to error factors such as battery characteristics, value of the charging current, and environmental temperature. However, since the error of the detection of -ΔV depends on the condition or deterioration level of the battery, arithmetic circuit 5 corrects the residual capacity value to 100% if a sum count value of the charging current when -ΔV was detected is greater than 70% of the value stored in second memory 7. In this case, an output of output circuit 8 is simultaneously corrected to 100%.

On the contrary, if the sum count value of the charging current has already exceeded the value stored in second memory 7 at the time when the voltage -ΔV is detected, the value of second memory 7 is set to 100%. This is to correct the error due to the error factors mentioned above, in which the sum of the residual capacity value exceeds the actual value. In this case, the sum of the charging current may be set not to exceed 100%. The operations above are explained in the flow chart of figure 2.

In the present embodiment, residual capacity display module A measures the battery voltage to detect -ΔV, but if recharger 13 is controlling -ΔV, a signal may be inputted from recharger 13 when -ΔV is detected.

Next, the main idea of the present invention will be explained. A detection of a battery voltage when the battery voltage has decreased and an operation of A/D conversion circuit 14 will be explained with reference to figure 3. When battery 1 is left untouched, or in other words, when it is being neither charged nor discharged, residual capacity display module A detects this through input circuit 10 and switches mode to low current consumption mode. A consumption current of residual capacity display module A in low current consumption mode is approximately 200-300μA, and

becomes a load discharge for battery 1. To prevent deterioration of battery 1 caused by prolonged load discharge, when the battery voltage converted to a digital value by A/D conversion circuit 14 falls below a predetermined level (1.0V for a single battery), arithmetic circuit 5 adjusts the output to cut off circuit 16 from H-level to L-level, and cuts the power supply to be inputted into residual capacity display module A. Due to this operation by cut off circuit 16, battery 1 is in a state of self-discharge, and deterioration or leakage will not occur.

An example of cut off circuit 16 is shown in figure 4. In this example, it is configured of switch circuit 16a and latch circuit 16b. An appropriate voltage to operate cut off circuit 16 is approximately 0.8V-1.0V for one cell, which is within a voltage range that will not cause battery 1 to reverse discharge.

Further, if a load short-circuit temporarily occurs and the battery voltage decreases, arithmetic circuit 5 operates cut off circuit 16 when the decrease in power source voltage continues longer than a predetermined time period. This is because it will malfunction if residual capacity module A is turned off. With the temporary load short-circuit in consideration, an appropriate time period in which the power source voltage continually decreases is 0.5 seconds or more.

The above-mentioned reverse charging means reversing a polarity of the battery, connecting it to a recharger, and forcing current to flow from a negative pole to a positive pole. As shown in figure 4, because the battery is being consumed, individual battery voltages begin to vary and the batteries are charged in reverse polarity from battery to battery. In the case of figure 5, the charging is performed in reverse polarity by other batteries because the voltage of battery 1b is low.

In the present embodiment, arithmetic circuit 5 detects the battery voltage and controls cut off circuit 16, but a battery residual capacity display device may comprise an external voltage detection device (not shown) to control cut off circuit 16. In addition, if the voltage increases due to recharging the consumed battery 1 which was consumed earlier, a reset is performed within cut off circuit 16 or by voltage detection device (A/D conversion circuit 14), and power distribution is resumed.

[Effects of the invention]

As described above, the present invention includes a voltage detection means for detecting a battery voltage and a cut off circuit for cutting off the electric supply from a battery to the residual capacity display at a time when a battery voltage detected by the voltage detection means falls below a predetermined level. When the battery voltage detected by the voltage detection means falls below the predetermined level, the cut off circuit cuts off the electric supply from the battery to the residual capacity

display device. As a result, battery deterioration due to consumption current by the residual capacity display device can be prevented.

4. A brief description of the diagrams

Figure 1 is a block diagram of an embodiment of the present invention.

Figure 2 is a flow chart of the embodiment of the present invention.

Figure 3 is a flow chart of the embodiment of the present invention.

Figure 4 is a relevant circuit diagram of the embodiment of the present invention.

Figure 5 is a schematic diagram of the embodiment of the present invention.

Figure 6 is a block diagram explaining the underlying condition of the present invention.

Figure 7 is a relevant circuit diagram according to the underlying condition of the present invention.

1 battery

5 arithmetic circuit

9 display

14 A/D conversion circuit

16 cut off circuit